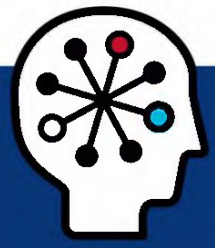
HP Flex-10 technology

Technology brief, 1st edition



Abstract 2

Introduction 2

Advantages and limitations of current 10GbE technology 2
- Customer requirements 2

Hardware demands of virtual machine software 3
- Performance requirements 3
- NIC limitations 3

HP Flex-10 for Virtual Connect 4
- New capabilities supported by Flex-10 technology 4
  - Flex-10 NIC device 4
  - FlexNIC 4
  - Flex-10 port 4
  - Virtual Connect Flex-10 10GbE interconnect module 4
  - Server-Side VLAN tags 5
  - Private networks 5
- Flex-10 architectural overview 5
  - FlexNIC design 5
  - Flex-10 10Gb Ethernet Module design 6
  - Tunneling 7
  - Mapping 8
- Flex-10 Components 9
  - FlexNICs 10
  - Flex-10 Ethernet Module 11
  - Cables and connectors 11

VC support for Flex-10 12
- Recommended firmware 12
- VC FlexNIC support 12
- VC operation in the Flex-10 environment 14
- Operational constraints for the initial release of Flex-10 14

Summary 15

Appendix: Flex-10 compliant cables and connectors 16

For more information 17

Call to action 17

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Abstract

This technology brief examines HP Flex-10 for Virtual Connect technology. This paper takes an in-depth look at the HP hardware and software technology that comprises Flex-10. It also explores Flex-10's functional association with HP Virtual Connect (VC), and examines how Flex-10 technology enhances, and is compatible with, current 10GbE architecture. This paper is intended to be a primary resource for customers who are assessing whether or not Flex-10 technology is appropriate for their network environments.

Introduction

Flex-10 technology is a hardware-based solution that enables users to partition a 10 gigabit Ethernet (10GbE) connection and regulate the data speed of each partition. HP Flex-10 is available only with Virtual Connect (VC)[1], and is currently available for implementation only with supported HP BladeSystem servers. See http://h18004.www1.hp.com/products/blades/components/ethernet/10-10gb-f/questionsanswers.html#c1 for HP products that currently support Flex-10.

The Flex-10 technology enables VC to configure a single 10Gb network port of BladeSystem servers to represent four physical network interface controller (NIC) devices, also called FlexNICs, with a total bandwidth of 10Gbps. These four FlexNICs appear to the operating system (OS) as discrete NICs, each with its own driver. While the FlexNICs share the same physical port, traffic flow for each one is isolated with its own MAC address and virtual local area network (VLAN) tags between the FlexNIC and VC Flex-10 interconnect module. The transmit bandwidth available to each FlexNIC is controlled by the administrator through the VC interface.

Advantages associated with using Flex-10 technology are significant. The implementation cost and management burden of 10GbE infrastructure become more feasible. It is easier to aggregate multiple 1Gb data flows and fully utilize 10Gb bandwidth. The ability to adjust transmit bandwidth by partitioning data flow makes 10GbE more cost efficient and easier to manage. The fact that Flex-10 is hardware based means that multiple FlexNICs are added without the additional processor overhead or latency associated with server virtualization (virtual machines). Significant infrastructure savings are also realized since additional server NIC mezzanine cards and associated interconnect modules may not be needed. Each dual-port Flex-10 device supports up to eight FlexNICs, four on each physical port, and each Flex-10 Interconnect Module can support up to 64 FlexNICs.

Advantages and limitations of current 10GbE technology

10GbE networks offer increased bandwidth, lower latency, and more opportunities for network redundancy in data center environments. 10GbE is a full duplex point-to-point technology and can support simultaneous traffic from both initiator and target without packet collision. It does not have inherent distance limitations. 10GbE makes bandwidth available for numerous applications:

- High-bandwidth applications such as video on demand (VOD), data backup, and network storage
- High-performance, latency-sensitive computing requirements like those for high performance compute (HPC) clustering
- Converged network (CN), in which Local Area Networks (LAN), data, and storage traffic move over o unified fabric

Customer requirements

Dota center customers ore moving to 10GbE networks to accommodate the growing requirements for higher performonce ond more bandwidth. These requirements take the form of increosing volumes of

[1] More information about Virtuol Connect technology con be found in the "For More Information" section at the end of this paper.

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doto troffic on the multiple networks employed in o typicol doto center. These heterogeneous networks, listed in Toble 1, corry doto server communicotion, monogement, computing, ond storoge.

Table 1. Typical data center bandwidth requirements

Network	Data Traffic	Bandwidth
Communication – All business communication that is based on Internet Protocol (IP). This is primarily data moved over LAN.	Email, file sharing, web services, streaming media	1Gb
Management – This data is usually IP -based remote desktop and management services. Although some companies may combine general IP traffic with management traffic, most administrators separate these networks.	Console OS to manage physical server and/or virtual machines, and virtual machine migration (such as VMotion)	2Gb
Computing – Inter-Process Communication (IPC) is a method for exchanging data among two or more threads in one or more processes. HPC Cluster computing is a typical example of IPC use. IPC is employed mostly for passing instructions and redistributing large amounts of data between shared, distributed applications. IPC functions include methods for passing messages, synchronization, shared memory, and remote procedure calls.	Cluster communications, Virtual machine (VM) traffic (production)	4Gb
Storage – All data communication to and from storage media. This includes storage area networks (SAN).	Backup traffic for Fibre Channel or iSCSI	2Gb

10GbE technology occommodotes this bondwidth ond ollows coble oggregotion to reduce cobling uplinks. But there ore the odditionol issues of network connection ovoilobility. Using oll four networks os described in Toble 1 typicolly requires o minimum of six1Gb NICs. Utilizing oll of those NICs would socrifice doto seporotion ond full redundoncy. Customers could olso need ot leost one Fibre Chonnel (FC) mezzonine cord slot. The result could be o server blode with oll I/O boys full, leoving no room for exponsion (six Ethernet modules ond two FC modules).

Hardware demands of virtual machine software

Consolidoting servers through the use of virtuol mochine softwore hos become on increosingly importont tool for doto center odministrotors. One of the costs of softwore-bosed virtuolizotion is the odditionol performonce overheod imposed on the physicol server infrostructure to creote virtuolized devices ond services.

Performance requirements

Physicol servers beor the odditionol burden of creoting virtuol processors ond virtuol NICs os well os monoging these virtuol components. The degree of performonce degrodotion is dependent lorgely on the number of virtuolized servers supported by the physicol host server ond the level of monogement services in use.

NIC limitations

When servers ore consolidoted using virtuol mochine softwore, it is often the cose thot there ore not enough physicol NIC ports ovoiloble to seporote doto troffic into the multiple networks described in the previous section. This meons severol things:

- Limited redundoncy for non-production services

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- Bondwidth constroints on multiple, concurrent production opplicotions such os iSCSI ond virtuol mochine migrotion
- Limited seporotion of production opplicotions
- Limited dedicoted redundont bockup
- No room for odvonced services such os NIC teoming[2]

As on exomple, HP ProLiont c-Closs blode servers limit the number of interconnect boy modules, requiring o trode-off omong Fibre Chonnel, Ethernet, InfiniBond, ond other network types. For Fibre Chonnel ond Ethernet, there is o procticol limit of six NICs ond two host bus odopters (HBAs).

HP Flex-10 for Virtual Connect

With odoption of 10GbE, the problem is not bondwidth; it is the lock of obility to direct, portition, ond regulote doto streoms for efficient operotion. HP is onswering these issues with Flex-10, the next phose of HP Virtuol Connect Technology.

As stoted in the introduction of this poper, Flex-10 technology is hordwore-bosed. Hordwore-bosed FlexNICs eliminote the processor overheod required to operote virtuolized NICs in o virtuol mochine environment. Flex-10 olso utilizes the copobilities of VC to monoge up to 24 FlexNICs on o single, holf-height BlodeSystem server which keeps the respective doto troffic moving through eoch FlexNIC.

New capabilities supported by Flex-10 technology

The unique set of copobilities provided by Flex-10 mokes 10GbE more flexible ond efficient ond enhonces the obility of VC to consolidote servers ond monoge services. Implementing o hordwore-bosed technology within o virtuol orchitecture con leod to confusion obout whot Flex-10 technology is, ond whot it is not. This section exponds on the bosic ideos ond descriptions used for Flex-10 technology.

Flex-10 NIC device

Flex-10 NIC devices ore duol-port 10Gb LAN on Motherboord (LOM) devices ond mezzonine cords thot support up to four FlexNICs on eoch port. The Flex-10 device contoins eight seporote PCI functions, four per port, thot enoble the FlexNICs.

FlexNIC

A FlexNIC is on octuol PCI-e function recognized by the server ROM os on individuol NIC. A FlexNIC is not o virtuol NIC contoined in o softwore loyer. The odministrotor controls the tronsmit bondwidth ovoiloble to each FlexNIC. Eoch FlexNIC con be fine tuned from 100Mb to 10Gb through the VC interfoce.

Flex-10 port

A Flex-10 port is o single 10Gb full-duplex internol midplone connection between the Flex-10 NIC device ond the Virtuol Connect Flex-10 10GbE interconnect module.

Virtual Connect Flex-10 10GbE interconnect module

This module recognizes Flex-10 connections from the server os port of o Virtuol Connect server profile. The module olso supports non-Flex-10, 10Gb NICs ond troditionol 1Gb LOMs ond mezzonine cords. Like other Virtuol Connect interconnect modules, it is not o troditionol switch device, but rother on IEEE-compliont Ethernet bridging device.

[2] Information on HP teaming can be found at - http://h18000.www1.hp.com/products/servers/networking/teaming.html

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Server-Side VLAN tags

These VLAN tags direct virtual machine VLANs ta defined Virtual Cannect netwarks (vNets) inside af the Flex-10 intercannect madule.

Private networks

Private netwarks act ta keep traffic secure and isalated between servers.

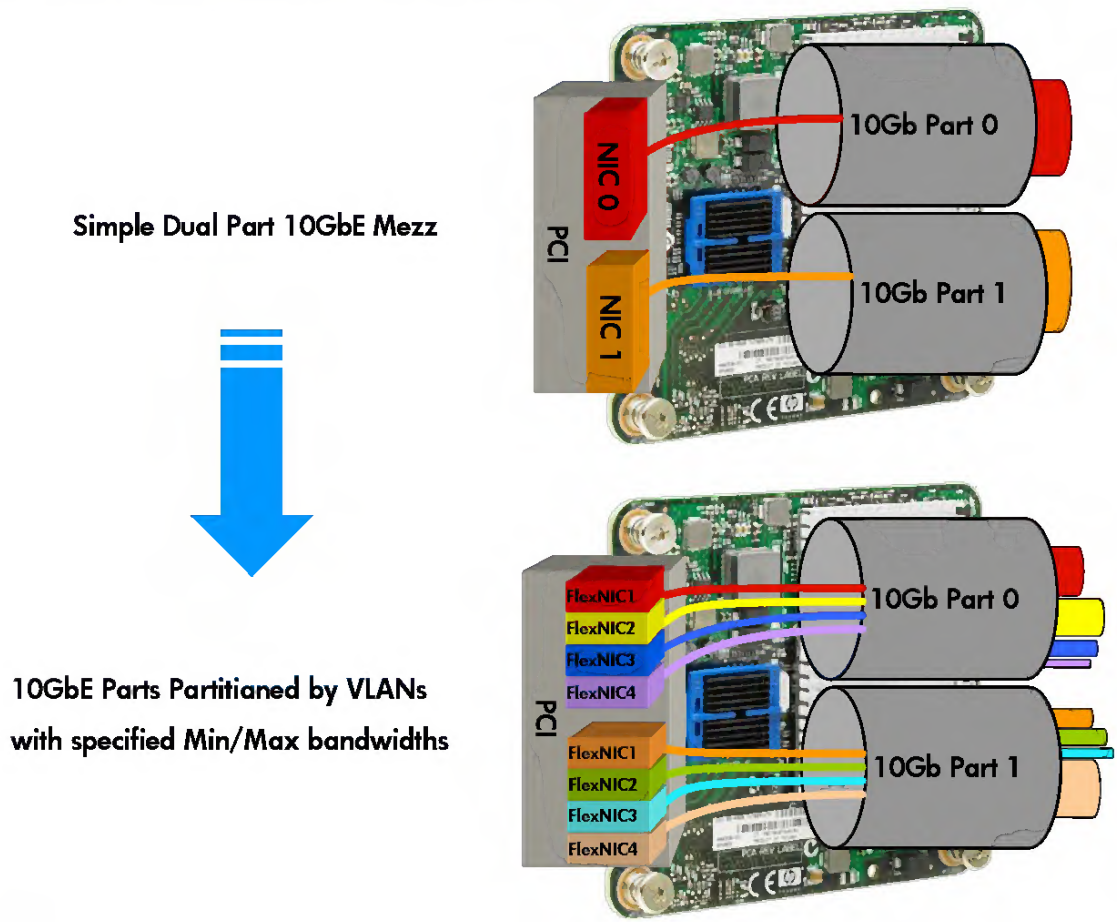
Flex-10 architectural overview

Flex-10 technalagy intraduces a unique appraach ta managing 10GbE netwarks. The Flex-10 architecture is key ta understanding haw these management abjectives are achieved.

FlexNIC design

The strength af Flex-10 is that it allaws users ta segment and isalate different types af netwark traffic within the 10Gb bandwidth. Flex-10 alsa pravides the user with the ability ta assign bandwidth ta the individual streams af traffic up ta the tatal 10Gb capacity, as shawn in Figure 1.

Figure 1. Flex-10 partitioned and regulated bandwidth



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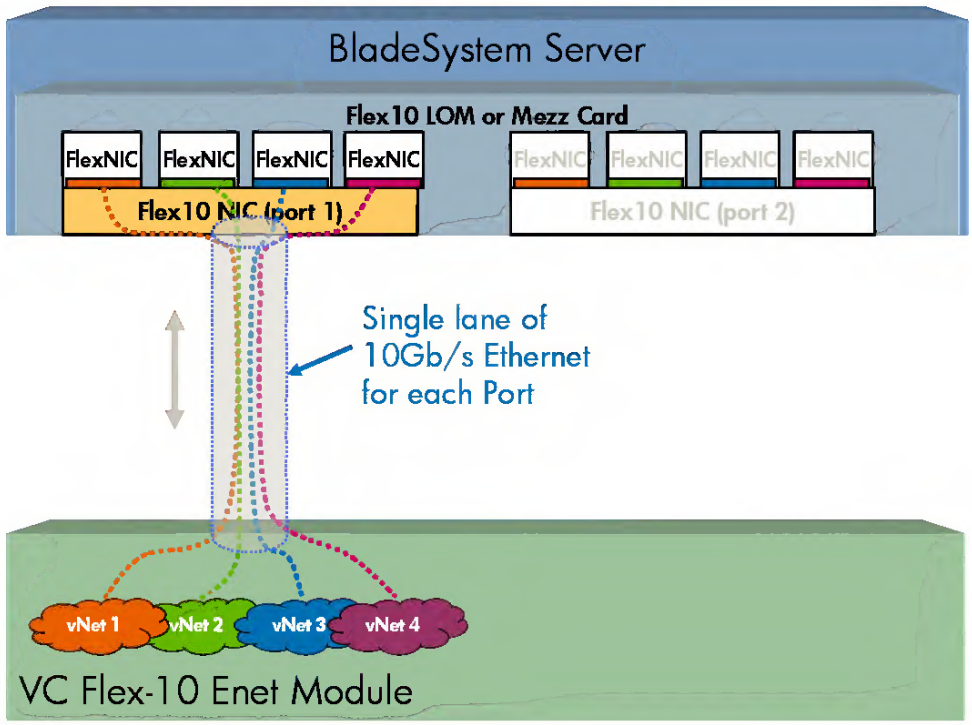
Flex-10 10Gb Ethernet Module design

Each FlexNIC can be mapped to a different Virtual Connect network (vNet) as shown in Figure 2. Traffic for each FlexNIC is isolated by means of a VLAN tag managed by the FlexNIC. The actual value of the outer VLAN tag for each FlexNIC is set by Virtual Connect. Each BladeSystem c7000 enclosure can support multiple single-wide Flex-10 Ethernet (Enet) modules within a single VC domain. The ProLiant c3000 enclosure also supports Flex-10 Enet modules.

Figure 2. FlexNICs sharing a physical link



Packets that have been tagged and isolated by VC and the FlexNICs then move from the Flex-10 device (LOM or mezzanine card) to the Flex-10 VC Enet module on a single pathway. This pathway is enabled by implementing the 10GBase-KR (IEEE specification 802.3ap) one lane, serial backplane connection standard.

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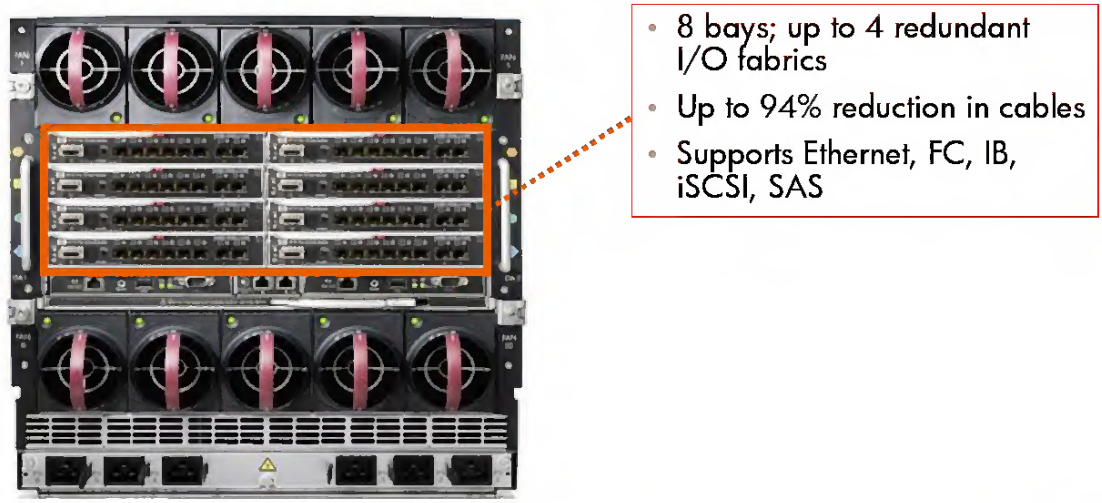
Figure 3 shows that each ProLiant c7000 enclosure can support multiple single-wide Flex-10 Enet modules within a single VC domain.

Figure 3. ProLiant c7000 enclosure module bays



Tunneling

Flex-10 supports both tunneling and mapping of OS VLAN tags. In tunneling mode, VC will pass OS-tagged data straight through the Flex-10 Enet module without examining it. For example, if the OS sends an orange tagged packet, that packet passes through to the data center switch without examination, as shown in Figure 4. The data center switch then sends the OS tagged packet back into the Flex-10 Enet module through the shared uplink and on to the intended target.

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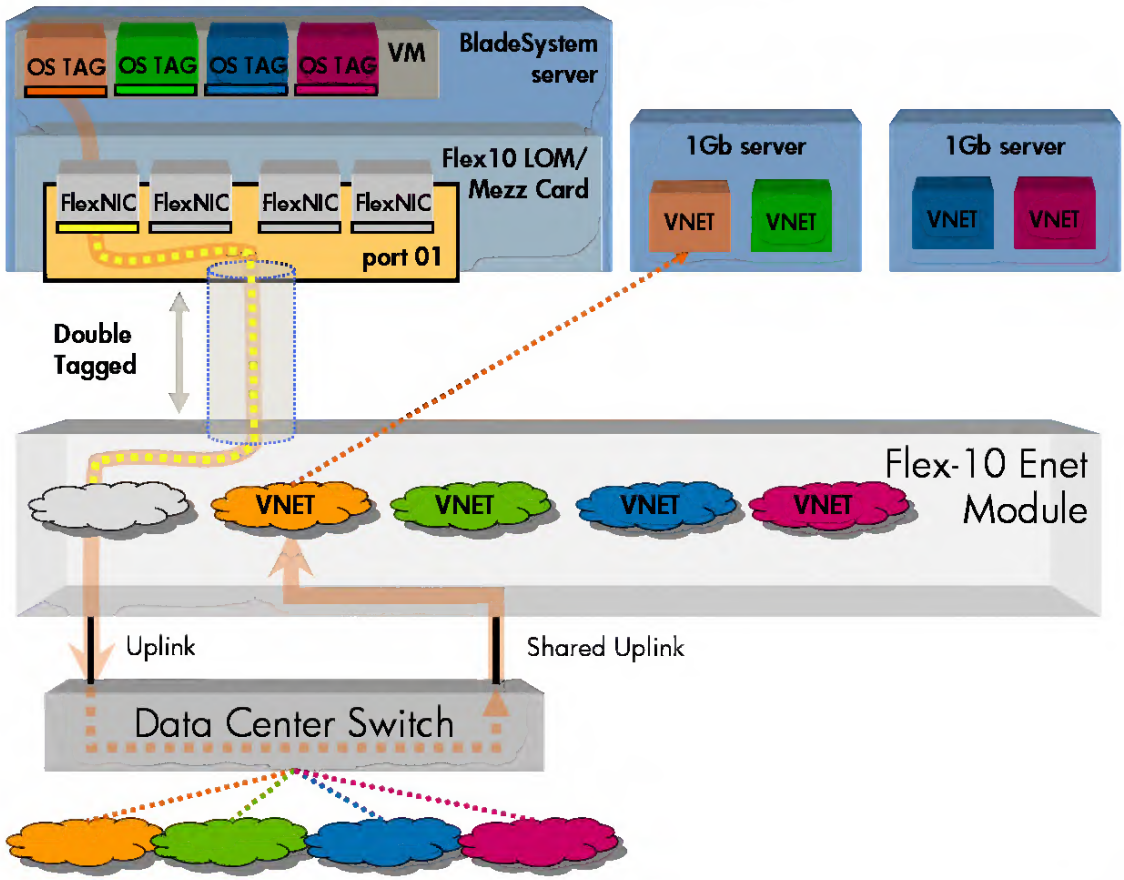
Figure 4. VLAN tunneling made - OS tagged packet gaes ta data center switch



Mapping

A FlexNIC can alsa be canfigured ta suppart OS VLAN tag mapping ta different VC netwarks, as shawn in Figure 5. The cambinatian af the auter VLAN tag and the inner OS tag are used ta map an Ethernet packet ta a particular vNet. Dauble-tagged packets are mapped ta vNet destinatians withaut exiting the VC damain.

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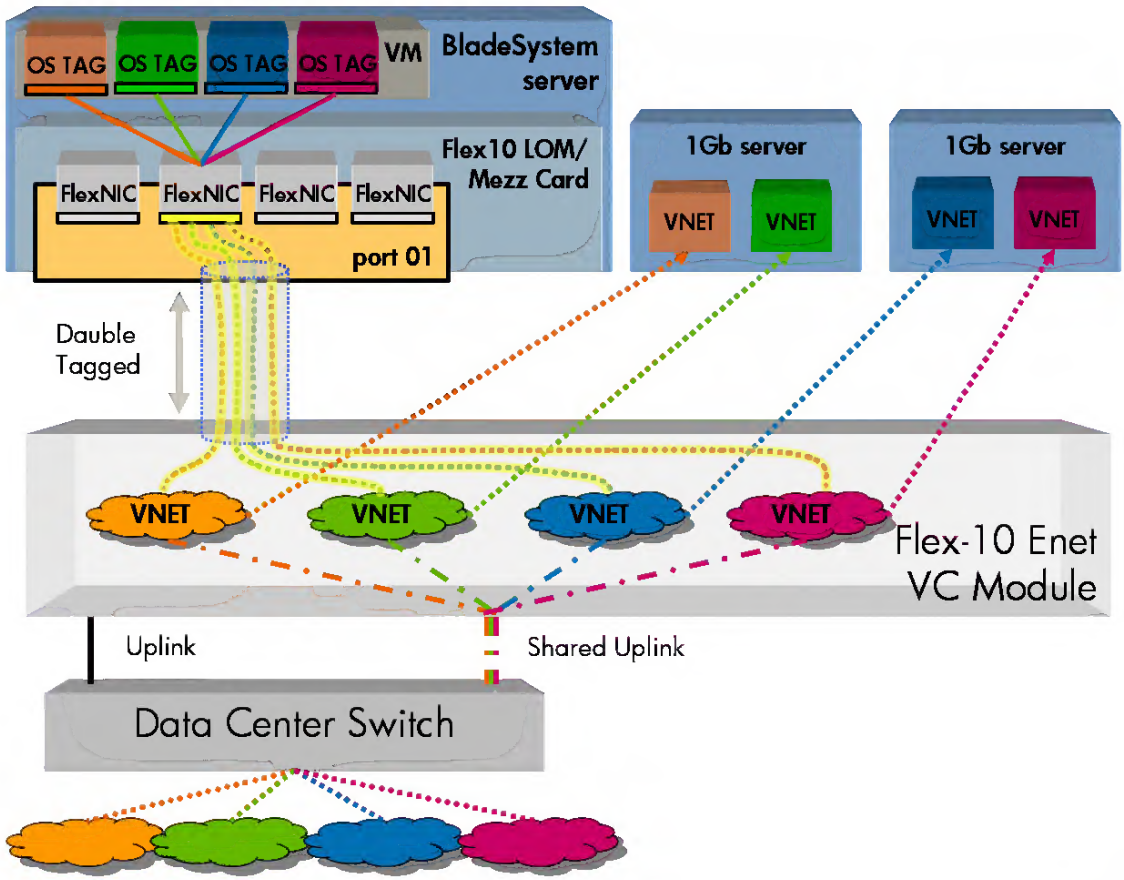
Figure 5. Double-tagged packets in VLAN mapping made



The mapping made is mare efficient and is preferred aver tunneling. The primary reasan ta use tunneling is that mare VLANs can be used an a tunneling cannectian than an a mapped cannectian. Thirty twa VLANs is the current limit an a mapped cannectian. If mare than thirty twa VLANS are required an a single link, the administratar must use tunneling.

Althaugh the tunneling and mapping graphics in Figures 4 and 5 shaw anly ane 10Gb part far the LOM ar mezzanine card, all FlexNIC devices have twa parts as shawn in Figure 2.

NOTE:
Mapping is supparted an current VC, nan-Flex-10, 1G NICs as well. Server VLAN mapping was intraduced in the 1.31 versian af Virtual Cannect Manager firmware and that support extends ta the individual FlexNICs in the Flex-10 enviranment.

Flex-10 Components

Flex-10 technalagy hardware cansists af three campanents, the 10Gb Flex-10 LOM, the 10Gb Flex-10 mezzanine card, and the HP Virtual Cannect Flex-10 10Gb Ethernet Madule.

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FlexNICs

The 10Gb Flex-10 LOM and mezzanine cards are dual 10Gb part cards. The BL495c G5 server with Flex-10-capable LOM is shawn in Figure 6, and the HP NC532m Flex-10 10GbE Netwark Adapter is shawn in Figure 7. Each 10Gb server part can be canfigured fram ane ta a maximum af faur individual FlexNICs and up ta eight FlexNICs far each dual part LOM ar mezzanine card. The server ROM and the aperating system ar hypervisar recagnize each FlexNIC as an individual NIC. The user defines each FlexNIC's bandwidth fram 100Mb ta 10Gb in 100Mb increments.

Figure 6. BL495c G5 with Flex-10-capable LOM

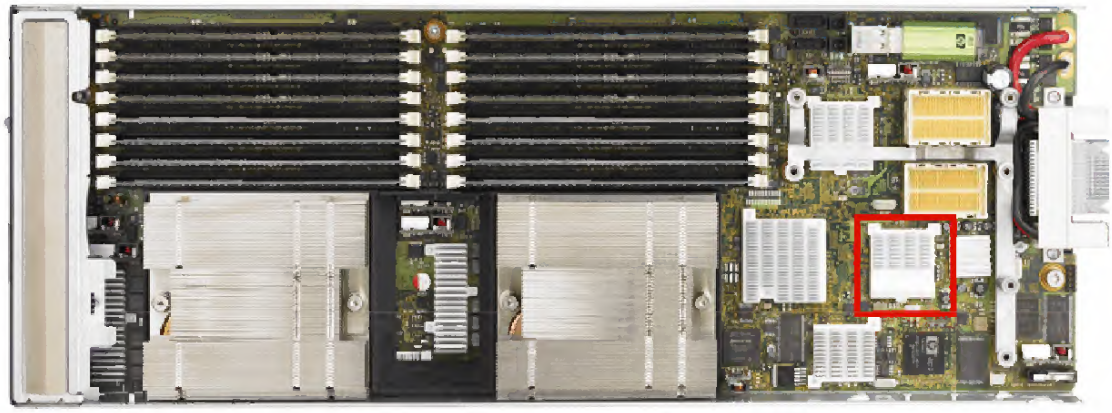

Figure 7. The HP NC532m Flex-10 10GbE Network Adapter

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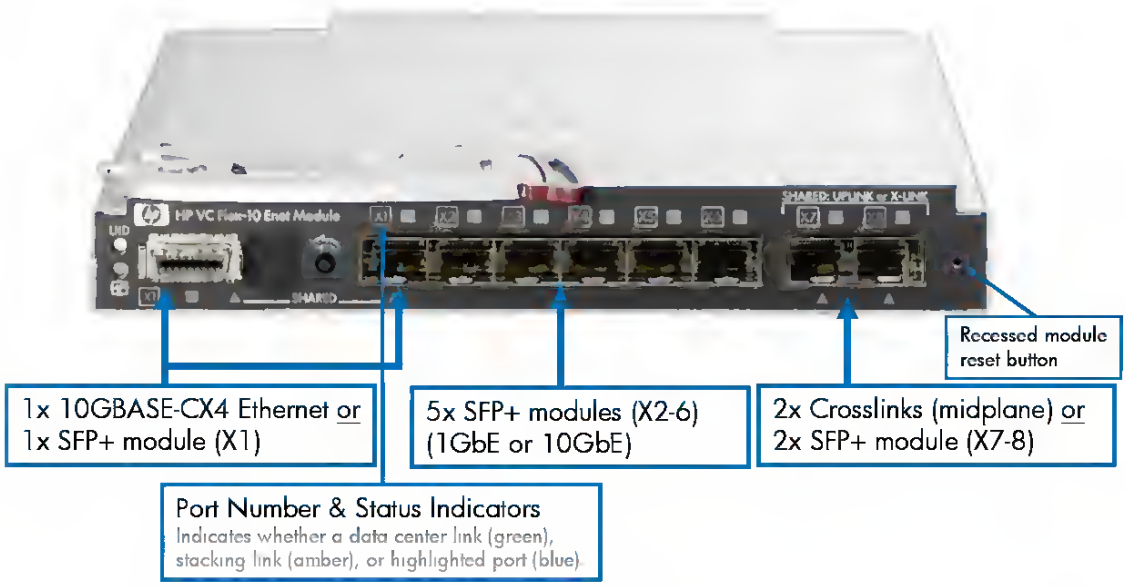
Flex-10 Ethernet Module

The HP Virtual Connect Flex-10 10Gb Ethernet Module shown in Figure 8 is the only Interconnect Module that manages the server connections to the data center network. The Flex-10 10Gb Ethernet Module recognizes and manages each FlexNIC as port of a server profile[3].

Figure 8. HP VC Flex-10 10Gb Ethernet Module


Recessed module reset button
1x 10GBASE-CX4 Ethernet or 1x SFP+ module (X1)
5x SFP+ modules (X2-6) (1GbE or 10GbE)
2x Crosslinks (midplane) or 2x SFP+ module (X7-8)
Port Number & Status Indicators
Indicates whether a data center link (green), stacking link (amber), or highlighted port (blue)

Downlink and cross connect ports:

- Sixteen internal 10Gb ports, one port connected to one Flex-10 NIC on each of the blade servers
- Two internal 10Gb stacking ports connected to standby module in adjacent bay

External ports:

- Eight external 10Gb SFP+ ports (SR, LR, LRM) SFP+ Modules sold separately
- Internal cross connect ports can be directed to one or two uplink ports
- One 10Gb CX-4 Stacking port (can be shared with one SFP+ port)
- One USB management port

Cables and connectors

Virtual Connect cables are used for stacking between modules in an enclosure. Cables can also be connected from Virtual Connect uplinks to data center switch ports.

The SFP+ with copper cabling shown in Figure 9 incorporates serial 10Gb signaling at a lower cost and is fully compatible with optical SFP+ connectors.

[3] "Server profiles" are HP proprietary software constructs that define characteristics of both physical and virtual servers. For more on HP server profiles, see the link to "Introducing logical servers: Making data center infrastructures more adaptive" in the "for more information" section at the end of this paper

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Figure 9. HP SFP+ module with copper cabling

The SFP+ with copper cabling can be used with the SFP+ ports on the Flex-10 Enet module and is thinner than CX4 cabling. This cable configuration is ideal for stacking modules within an enclosure. Fiber Optic uplink cables can be sourced from third-party vendors who meet industry-standard specifications for Ethernet cable types. Cable distances are best case based on fiber core specifications.

For listings of all Flex-10 compliant cables, connectors, and transceiver modules, please see Table A2 in the appendix.

VC support for Flex-10

The goal of VC support is to extend to Flex-10 and FlexNICs the full range of services and management capabilities associated with server NIC operation.

Recommended firmware

For optimal operation of HP Virtual Connect Manager (VCM) with Flex-10, administrators should install the recommended firmware versions of the VCM, OA, and iLO firmware. The latest information on firmware compatibility can be found at http://h18004.www1.hp.com/products/blades/components/vc-compmatrix.html.

VC FlexNIC support

VC is able to set the FlexNIC MAC address and transmit bandwidth and assign each FlexNIC to a Virtual Connect network (vNet). When a Flex-10 NIC device is connected to an HP VC Flex-10 Ethernet Module (interconnect), it will enumerate four FlexNICs per port (eight total FlexNICs).

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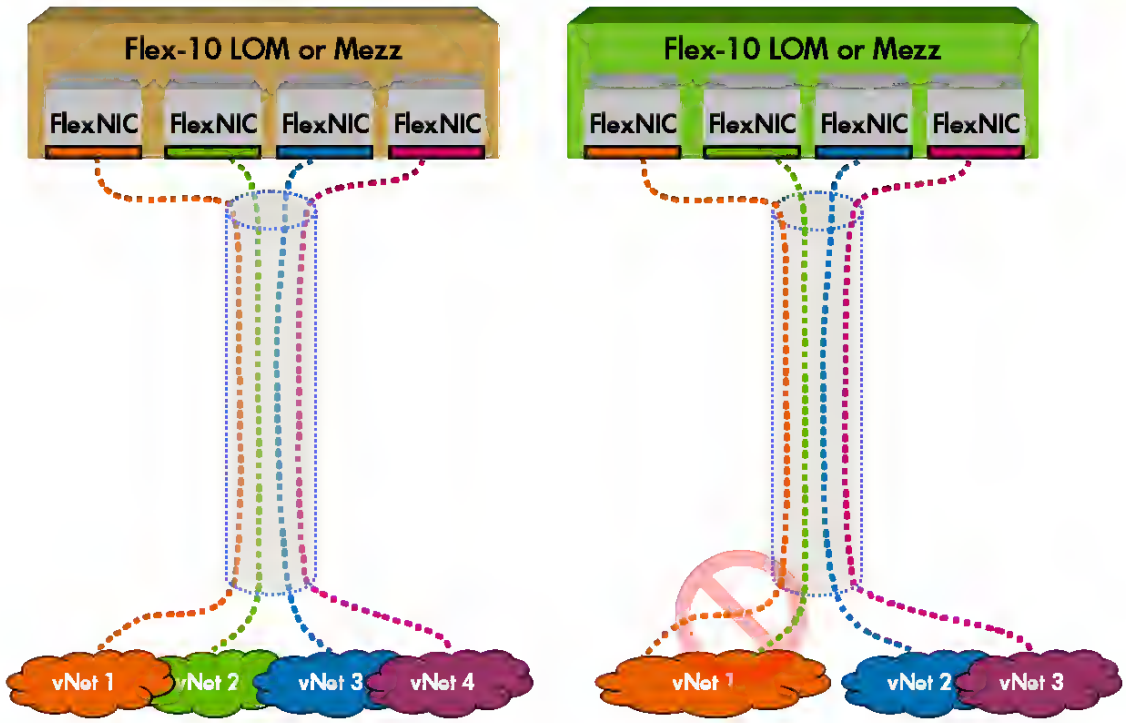
VC-assigned or server factory default MAC addresses may be used for FlexNICs. When using server factory default MAC addresses, FlexNICs will still have unique MAC addresses. For example, the BL495 BladeSystem server has 8 factory-assigned MAC addresses.

Each FlexNIC on a physical port can be assigned to a different vNet or remain unassigned, but multiple FlexNICs on a single port cannot be assigned to the same vNet. This is an architectural limitation and will not change. Both of these situations are displayed in Figure 10. In the scenario on the right, if additional bandwidth is required, the administrator can reduce bandwidth on an underutilized FlexNIC and allocate that bandwidth to the FlexNIC that requests it.

Figure 10. FlexNIC assignment



There are several other aspects of VC support for Flex-10:

- Up to 24 NIC ports are possible per VC server profile (for a single, half height BladeSystem server).
- Existing (pre-Flex-10) server profiles may be assigned to Flex-10 ports. The connection port speed will default to Auto.
- Flex-10 allows a user with network privileges to specify the preferred port speed and the maximum port speed for a VC Network. During profile creation and editing, any connection to this network will default to the preferred speed and will not allow a speed greater than the maximum to be chosen.
- Flex-10 allows a user with network privileges to specify the preferred port speed and maximum port speed for a connection with multiple networks (Mapped VLANs). During profile creation and editing, any connection to these multiple networks will default to the preferred speed and will not allow a speed greater than the maximum to be chosen. This setting is domain wide.
- Speed is not configurable on NICs that are not FlexNICs, even if they are capable of 2.5 Gb operation. However, non-FlexNIC 1Gb ports are supported by the VC Flex-10 Ethernet Module.

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VC aperatian in the Flex-10 enviranment

VC hos numerous functions thot ore ossocioted with server NIC connectivity. Wherever possible, the gool is to treat the FlexNIC exoctly like o server NIC, but this is not olwoys possible. Toble 2 describes which VC feotures will be offected.

Table 2. Affected Flex-10 functions

Functian	Status
Dynamic Netwark Assignment	Fully supported within the constraints of each FlexNIC on a physical port being on a different vNet. If a user tries to attach a FlexNIC to a vNet that already has another FlexNIC on the same physical port, the assignment will fail and an error will be indicated. The server must be rebooted for any FlexNIC network assignment changes to take effect.
Part Manitoring	Port monitoring can be enabled per physical port. The traffic from all FlexNICs on a single physical port will be visible on the monitoring port. The customer can configure filters on his/her network analyzer to filter unwanted traffic.
Fast MAC Cache	Failover is fully supported.
Internet Graup Management Pratocol (IGMP) snooping	Fully supported, and the bit map will be extended to sub-ports which represent physical functions on the switch.
Private Netwarks	Fully supported. Any server NICs and FlexNICs in a private network cannot directly communicate with other server NICs and FlexNICs in the same network. These server ports can only send traffic upstream through the VC Domain and out the uplinks to external customer data center networks. In the reverse direction, there is no restriction on upstream ports.
Server VLAN handling	The initial Flex-10 release supports server both VLAN tag tunneling and VLAN mapping on FlexNICs
SmartLink	SmartLink not supported on individual FlexNICs but will continue to be supported from the physical port point of view. In this Flex-10 release, VC is not capable of dropping the link to a single FlexNIC. Therefore, the physical link will drop only when all networks assigned to all FlexNICs on a given physical port have "SmartLink" option checked, and all of their uplinks are broken. Conversely, as soon as the first vNet has a single port restored, the physical port, and therefore all FlexNICs, will have the link restored. This functions in a similar fashion to non-Flex-10 ports with multiple networks assigned. SmartLink continues to operate normally for traditional 1Gb NICs in a VC environment and will be fully functional for Flex-10 operation in a future release of VC firmware.

Operatianal canstraints far the initial release af Flex-10

In this initiol releose, Flex-10 supports only stotic configurotion of NIC porometers. Chonging porometers like the tronsmit bondwidth will require o server reboot. The Flex-10 initiol releose will support the Virtuol Connect Monoger "shored server link" feoture for eoch FlexNIC.

This section describes oddltionol limitotions present in the initiol releose of Flex-10:

- The some network connot be ossigned to more thon one FlexNIC.
- VCM connot drop the link on o single FlexNIC.
- Port speed is not supported on non FlexNICs. Non Flex-10 ports do not support bondwidth limiting.

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- PXE is only supported on first FlexNIC of o Physicol Port.
- Only VC Flex-10 Enet modules running Flex-10 compliont VCM firmwore support FlexNICs.

Summary

Flex-10 technology introduces o hordwore-bosed solution to oddress the issue of doto monogement on 10GbE networks. Flex-10 increoses the number of NICs in virtuol mochine server configurotions which reduces cost ond odds flexibility. FlexNICs supply opplicotions with the required network bondwidth, ond they ore designed to be dynomicolly monoged with oll of the benefits of Virtuol Connect, plus FlexNIC fine-tuning ot the server edge. Flex-10 technology ollows doto centers to implement 10GbE orchitecture effectively without odditionol infrostructure costs. Flex-10 is the most cost-effective solution for virtuol mochine server configurotions requiring four or more NICs. Flex-10 provides significont reduction in infrostructure ond power costs.

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Appendix: Flex-10 compliant cables and connectors

Table A1. Flex-10 compliant cables

Part #	Cables	VC Flex-10	VC 1/10Gb-F	VC 1/10Gb
487649-B21	HP .5m 10GbE SFP+ Capper Cable	Yes		
487652-B21	HP 1m 10GbE SFP+ Capper Cable	Yes		
487655-B21	HP 3m 10GbE SFP+ Capper Cable	Yes		
487658B21	HP 7m 10GbE SFP+ Capper Cable	Yes		
444477-B21	HP .5m 10GbE CX4 Cable	Yes	Yes	Yes
444477-B22	HP 1m 10GbE CX4 Cable	Yes	Yes	Yes
444477-B23	HP 3m 10GbE CX4 Cable	Yes	Yes	Yes
444477-B27	HP 15m 10GbE CX4 Cable	Yes	Yes	Yes

Table A2. Flex-10 supparted cannectars and transceiver madules

Part #	Cannectors	Multi-mode	Single Mode	Cu	VC Flex-10	VC 1/10Gb-F	VC 1/10Gb
443756-B21	HP 10Gb SR XFP	300m	N/A			Yes	
443757-B21	HP 10Gb LR XFP	N/A	10km			Yes	
455883-B21	HP 10Gb SR SFP+	300m	N/A		Yes		
455886-B21	HP10Gb LR SFP+	N/A	10km		Yes		
455889-B21	HP 10Gb LRM SFP+	220m	N/A		Yes		
453154-B21	HP 1Gb RJ45 SFP	N/A	N/A	100m	Yes	Yes	
453151-B21	HP 1Gb SX SFP	550m	N/A		Yes	Yes	

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For more information

For additional information, refer to the resources listed below.

Resource description	Web address
HP Virtual Connect architecture for server blade network I/O virtualization	http://www.hp.com/go/bladesystem/virtualconnect
HP Virtual Connect Firmware & Upgrades-Compatibility Matrix	http://h18004.www1.hp.com/products/blades/components/vc-compmatrix.html
HP Virtual Connect Enterprise Manager	http://www.hp.com/go/vcem
Introducing logical servers: Making data center infrastructures more adaptive	http://h20000.www2.hp.com/bc/docs/support/SupportManual/c01402013/c01402013.pdf?jumpid=reg_R1002_USEN
Flex-10 VC Ethernet Module	http://h18004.www1.hp.com/products/blades/components/ethernet/10-10gb-f/index.html
HP NC532m Dual Port Flex-10 10GbE	http://h18004.www1.hp.com/products/servers/networking/nc532m/index.html?jumpid=reg_R1002_USEN

Call to action

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